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FOG SIGNALS AND METEOROLOGY.

PROF. H. A. HAZEN.

IT has been ascertained that even the light of the sun entirely fades out after penetrating a mile of fog; and the most intense artificial illumination is lost at a much less distance. In a fog, then, the light-houses, set to warn mariners of dangers unseen and unexpected, become of no avail, and resort must be had to other methods of warning.

On the night of Nov. 6, 1880, in a dense fog, the steamer "Rhode Island" was wrecked on Bonnet Point, in Narragansett Bay, and $1,000,000 in property was lost, besides, the lives of all on board were seriously imperiled. This wreck occurred only a little more than a mile from a fog signal, a Daboll trumpet set at Beaver Tail Point for warning of just such danger. This trumpet was in full blast at the time, and under most conditions could be heard easily six to eight miles in its front.

About midnight of May 12, 1881, in a dense fog and dead calm, the propeller "Galatea" of over 1,500 tons burden, with a full load of passengers and freight, bound through Long Island Sound from Providence to New York, grounded about 600 feet behind the fog signal on Little Gull Island. In this case the signal was a steam siren, which has been heard under favoring circumstances to a distance of 25 miles. A special investigation showed that at this very moment the siren was in full blast as was testified to by ship captains passing at the time, and also by others who were awake and in a position to hear at distances of 6 to 8 miles in an opposite direction from the "Galatea." I am sure no further illustrations are needed to show the extreme importance of a careful study of this question of the aberrations of fog signals for the purpose of securing

greater safety to lives and property in these fogs which are so common along the northern coast.

In October, 1893, the present writer was invited to accompany an expedition on the schooner "Clover," arranged and fitted out by the Light House Board of the United States for the express purpose of studying the many aberrations of the various fog signals on the New England coast. This paper is made up from reports rendered in December, 1893, to the United States Weather Bureau, to the Light House Board, and from special studies at that time. If any one will read up the various experiments that had been made up to that time, he will find most serious contradictions and very great confusion in nearly all investigations. It is a singular fact, that though experiments were carried on simultaneously in England by Prof. Tyndall, and in this country by Prof. Henry, yet the results obtained gave rise to theories which were opposed to each other, and aroused a controversy between these masters of investigation which was never settled. It behooves all who would enter this field, to take warning from these experiences and to base every statement upon facts which cannot be controverted. It is best to go over a portion of this ground already covered, as we shall entirely fail in comprehending the true needs of the problem before us unless we keep in mind what has been done by others, and unless we familiarize ourselves with the difficulties already encountered. It may be said that there is hardly one single point in the attempted explanation of the aberrations of fog signals that has been established beyond a peradventure.

The Source of Sound.

Fog signals have been made by bells, cannon, steam whistles, air trumpets, and steam sirens. The sounds from a bell as ordinarily rung or struck have but little penetrating power and are easily drowned by the noise of a surf. They are used as auxiliary to other signals. Cannon give too short a sound and are not used in this country. Steam whistles are like those used upon locomotives and range from 8 to 18 inches in diameter. The great advantage of the steam whistle is that it can be heard on all sides of an island or of a promontory projecting into the water. It is safe to say, that

if there had been a 12-inch steam whistle at the points mentioned above, neither of the accidents would have happened. In fact, at Beaver Tail Point, the Daboll trumpet, sending its sounds clearly in one direction only, has given way to a 12-inch steam whistle. It is very easy to see how useless it is to try to study the conditions under which the previous wreck occurred near this point, with a fog signal which differs so widely from the one formerly in use.

The Daboll trumpet has a vibrating reed, and its sound is intensified by the trumpet. Its principal merit consists in the cheapness with which it can be run. The steam siren, made after plans submitted by Prof. Henry, is acknowledged by all to have the greatest intensity of sound of any method yet adopted. Even Prof. Tyndall gave the palm to this wonderful instrument which has been heard as far as 30 miles under favorable circumstances.

Penetrating Power of Signals.

The whistle has to fill the whole hemisphere above with sound, and we would naturally expect that it would have much less carrying power than either of the trumpets in any given direction. Prof. Henry, in some researches with an artificial ear, found the penetrating power of these 10, 9, 5, in the order : siren, Daboll, whistle. A more recent study has given the relative numbers 9, 4, and 7 respectively. These results would seem to show a serious error somewhere, as in the one case the power of the Daboll was twice that of the whistle, while in the other it was only about one half the whistle. In my own investigations, the whistle had a penetration of only one half to one third that of a first-class steam siren. These discrepancies are due to a want of care in comparing the instruments under like heads of steam, or under like conditions of topography, wind velocity and direction, etc.

Fog.

It is very essential that we keep in mind, as far as may be known, the conditions under which fog forms. This is especially needed if these meteorologic conditions have anything to do with the failure of these signals. A great deal of the difficulty and confusion that has arisen in studies of this kind has been

due to ignorance of these and other meteorologic conditions. Prof. Henry says: "Fogs are in all cases produced when cold air is mingled with warm air saturated with moisture." Another writer ascribes fog to a cold north wind blowing into the rear of a storm. A familiar illustration of this effect may be cited in the reputed snow-storm which fell in a stifling ball room in St. Petersburg upon opening several windows and allowing free ingress to the very cold outside air. Prof. G. G. Curtiss has also recently stated that he remembers miniature snow storms in his mother's kitchen, on washing days when the outside door was opened. It is well known, also, that this is the old Huttonian theory of the cause of rain. It is highly probable that the only fog or precipitation that could be produced under these circumstances would be along a very limited surface in the atmosphere where a cold wind in rapid motion impinges upon warm saturated air. I have tried this experiment in a room full of steam but have never succeeded in obtaining a fall of rain drops. Inquiries at laundries have also given negative results.

In a fog, the air is usually very still and that, too, not merely at the earth but up to some height above the fog, so that in most cases the necessary cold wind is lacking. Even if there should be a partial condensation into fog the tendency would be for the liberated latent heat to dissipate the fog. It is generally conceded to-day that this explanation will not account for the formation of an extensive fog.

In all cases, almost without exception, the fog will occur while the air is nearly saturated from the recent passage of a storm. The other conditions are a calm air, where different strata are not mixed, and a clear sky above, thus permitting rapid radiation of heat to the sky, and this cooling results in the fog. It will be seen that, if this view be correct, there must be quite an abnormal gradient in temperature vertically ; and, if there is any action in such strata in refracting sound, it should be greatest in a fog. On the contrary, it has been found that the existence of fog does not seem to impede or deflect the sound ordinarily.

The Effect of the Wind.

In all studies of this problem of the aberration of fog signals, the effect of the wind has been the most prominent factor.

Most extraordinary assumptions have been made in order to explain away difficulties. It is impossible, in the scope of this paper, to more than mention a few of the aberrations that have been noted and ascribed to the effect of the wind. I will quote from the writings of Gen. Duane and Prof. Henry.

"There are six steam fog-whistles on the coast of Maine; these have been frequently heard at a distance of twenty miles, and as frequently cannot be heard at the distance of two miles, and this with no perceptible difference in the state of the atmosphere. The signal is often heard at a great distance in one direction, while in another it will be scarcely audible at the distance of a mile. This is not the effect of wind, as the signal is frequently heard much farther against the wind than with it. For example, the whistle on Cape Elizabeth can always be distinctly heard in Portland, a distance of nine miles, during a heavy northeast snow-storm, the wind blowing a gale directly from Portland toward the whistle."

"The most perplexing difficulty, however, arises from the fact that the signal often appears to be surrounded by a belt, varying in radius [width] from one to one and a half miles, from which the sound appears to be entirely absent. Thus, in moving directly from a station, the sound is audible for the distance of a mile, is then lost for about the same distance, after which it is distinctly heard for a long time. This action is common to all ear-signals, and has been at times observed at all the stations, at one of which the signal is situated on a bare rock twenty miles from the main-land, with no surrounding objects to affect the sound."

"That fog has no great effect can easily be understood when it is known that even snow does not deaden sound, there being no condition of the atmosphere so favorable for the far-reaching of sound signals as is that of a heavy northeast snow-storm [with opposing wind], due supposedly to the homogeneity produced by the falling snow."

"The worst conditions for hearing sound seem to be found in the atmosphere of a clear, frosty morning on which a warm sun has risen and has been shining for two or three hours."

The signal at Whitehead is on a small island off the coast of Maine on the southeast slope of the rock and about 75 feet above mean tide. Prof. Henry, in a thick night fog in 1872, on

approaching the station, heard the signal, a 10-inch steam-whistle, at a distance of six miles; he continued to hear it for three miles, when the sound suddenly ceased, and was not heard again within one quarter mile of station, though the signal had been sounding the whole time. The wind was from the south or almost opposed to the sound. During all the time the fog-signal keeper could hear the sound of the steamer's 6-inch whistle. In 1877 Prof. Henry steamed west-southwest directly to windward from Whitehead; when he was between a quarter and a half mile distant, he lost the sound completely and it could not be heard for about a mile, when it was faintly heard and continued to increase in loudness until he was four miles off when it was again clearly heard. On going back over the course the same phenomena were observed in reverse order.

These extracts taken from scores of similar experiences must suffice us for the present. It should be noted that almost nothing is known of the effect of a *favoring* wind at Whitehead. It is probable that the belt of silent area mentioned extends for only a short distance on either side of a south line from this station. Nothing is said about the velocity of the wind. It is not certain that the effects are produced by wind in a single direction only. We are told very little of the topography save that the signal is on the southeast slope of the rock.

It is not possible to more than allude to the supposed action of the wind in these cases. It is assumed that the velocity of the wind must always increase with height, owing to friction with the earth, and the effect of this change in velocity is to refract or tilt the sound upward when the wind is blowing toward the signal; but the refraction will be downward with a favoring wind. Now, suppose the wind is blowing toward the signal, the tendency will be for the sound to be tilted upward away from the earth; but suppose there is another wind up aloft blowing in the opposite direction from the lower wind or with the sound; this upper wind would tilt the sound back again across the lower wind and thus the sound would be heard after a little area of silence had been crossed. It is doubtful if there has ever been a much more extraordinary series of suppositions in meteorology to explain a difficulty. The wind does not have a steady motion in different strata. It is the most uncertain and fickle of all meteorologic phenomena. Even if there were

any such effect by a lower wind it is impossible for us to suppose that there can be an upper wind conveniently blowing in the opposite direction or that this wind could tilt the sound down through the lower opposing wind.

If any one will study the winds from a meteorologic standpoint, and try to ascertain the real conditions under which they act, it is highly probable that he will abandon this wind refraction theory as absolutely untenable. It is a remarkable fact that no attempt has ever been made in this country to ascertain quantitatively just the action of the wind as regards velocity and direction in different strata, and above all to connect this action directly and on the spot with the aberrations noted.

Again, in some researches abroad, it was determined that sounds were best propagated at right angles to the wind; but this result must have been obtained from laboratory experiments, or some source of error must have entered the research. Prof. Henry found that the sound was heard nearly twice as far with the wind as against it, and the area of sound was an oval. He also found that on some days the area of the oval was four or five times as great as on others. This was a most remarkable result, and demands careful study. Was there a flocculent condition of the atmosphere on some days which retarded the sound? This is the view advanced by Prof. Tyndall to explain many of the difficulties. Or, was there a peculiar condition of the atmosphere called *audibility*, which caused a greater penetration of sound on some days than on others? Or, were there conditions of topography or environment different at different signals?

Topography.

It is a singular fact that this question of topography has been usually dismissed with a statement that it does not enter the problem, but the evidence is cumulative the other way. In the English experiments the apparatus was placed upon the edge of a cliff 235 feet high. It would seem impossible to estimate or even imagine the overshoots, the reflections, the interferences, the echoes and aberrations in general, that would occur under such conditions. There is no doubt that nearly all the controversy between these prominent and world-renowned investigators, Prof. Henry and Dr. Tyndall, arose from this extremely faulty environment of the English apparatus.

At Beaver Tail Point, where there is a 12-inch steam whistle, the land back of the point rises abruptly above the water about 20 feet. It was found that at a distance of only 700 feet from the whistle the sound died down from about 10 to 1, in going less than 250 feet. Here was a plain case of an overshoot. At Boston Light, on Great Brewster Island, about one half mile from the siren, the sound died down from about 5 to 0 in going only a few feet over the island cliff. Reflections of sound could be very plainly heard from houses, cliffs, and from sails of vessels. This question of topography is most assuredly an important one and cannot be ignored. In some cases it has been found that building a tall fence near a fog signal has served to modify and even to obliterate a silent area. The points at which the silent areas have been noted most persistently have been at Cape Elizabeth, Me., 143 feet high, and at Whitehead, 74 feet. The phenomenon of the "silent area" was not noted once in several weeks cruising along the New England coast, and in no case was there an extensive cliff near the signal.

Spread of the Sound.

One of the more important points developed and announced by Prof. Henry related to the spread of the sound. He says, "Even with the trumpet, the sound so diverges from the axis as to be efficient even in the rear of the instrument." Again, "This result was corroborated by subsequent experiments in which a whistle was heard nearly as well in the rear of a reflector as before it." "Upon this and all the subsequent experiments, as it will appear, the principle of reflection as a means of re-enforcing sound is but slightly applicable to fog signals." Prof. Henry also suggests that while a reflector is of service with faint sounds, yet with the louder sounds and at some distance from the source, there appears to be little difference whether one is in the front or rear of the trumpet. It must be admitted that this statement is one of the most puzzling in all these researches, and, more than this, its importance cannot be exaggerated. Gen. Duane, one of the first experimenters in this line early abandoned the use of trumpets for re-enforcing the sound of a signal. As already mentioned, there is no doubt that the "Galatea" would have been entirely safe if there had been a whistle on Little Gull Island instead of a trumpet.

A trumpet actuates only about $\frac{1}{16}$, or, at most, $\frac{1}{8}$ of the sphere, and, on any principle of the application of energy, it must send its impulses farther in its axis than in any other direction; moreover, a steam whistle sending its sound in all directions equally does not appear to reach much more than $\frac{1}{8}$ the distance that a first-class siren does.

But this is not all: in other researches Prof. Henry showed that, taking the intensity of sound in the axis of a trumpet as 8, at the same distance, but 30° from the axis, the sound was 7.1; at 60° it was 6.5; at 90° it was 5.5, and at 120° it was 4.0.

In England, it was deemed necessary to mount the siren upon a turn table which could be turned in an arc of 210°, and it could also be depressed. A watch suspended by a string in free air was barely heard 34 inches. In a rough cone of paper it could be heard to the end of the room 18 feet, and could have been heard 10 to 15 feet farther. In the rear of the cone it was just barely heard 12 inches. Nor does it help matters any to place the hearing circle at a great distance from the trumpet, for it is just there that the trumpet has its greatest power. At Little Gull Island, I heard a second-class siren distinctly six miles in its axis, but less than 800 feet in its rear. At Boston Light, a first-class siren was heard easily at 13 miles in front but less than a mile in the rear.

A careful search has failed to show any but the crudest experiment to prove this hypothesis, and that, once only, when a whistle was placed in the focus of a parabolic reflector. In this case, the reflector was out in the open and had no buildings in the rear. The intensity of sound was taken with an artificial ear (tympanum). The direction of the wind was in all probability from the front to the rear of the reflector. Whatever the explanation of these anomalies there cannot be the slightest doubt that a trumpet, especially if it has a tall building to the rear, cannot be heard to the rear beyond a few hundred feet, except on rare occasions when there is a favoring wind from the trumpet to the ear. At Little Gull Island, I rowed or steamed with a launch several times from a point in front of the siren to the rear, and each time, without exception, no matter what the direction of the wind was, the sound died down very markedly the moment any portion of the building in which the trumpet was situated came between me and the end of the trumpet.

Aerial Echoes.

It is well known that one of the most puzzling facts connected with researches in the aberrations of fog-signals has been an aerial echo coming in from the ocean from the direction in which the axis of the siren pointed, or, if the siren pointed vertically upward, coming from all around the horizon. Dr. Tyndall says of these: "On the day our observations at the South Foreland began, I heard the echoes. They perplexed me. I heard them again and again. The echoes have manifested an astonishing strength, when the sea was of glassy smoothness. Rightly interpreted and followed out, these aerial echoes lead to a solution which penetrates and reconciles the phenomena from beginning to end. On this point I would take the issue of the whole inquiry, and to this point I would, with special earnestness, direct the attention of the Light House Board of Washington. The echoes afford the easiest access to the core of this question, and it is for this reason that I dwell upon them thus emphatically." I presume it is generally known that Dr. Tyndall looked to acoustic clouds as the cause of all these echoes and also as explaining in the minutest detail all the silent areas and aberrations that have been noted.

Prof. Henry in his earlier studies regarded these as "ocean echoes," that is, echoes returned by the waves or swells of the ocean, but after farther study he abandoned that view. His very last utterance on this whole subject, so far as published, was as follows, in October, 1877: "As a provisional explanation, the hypothesis has been adopted that in the natural spread of the waves of sound, some of the rays must take such a curvilinear course as to strike the surface of the water in an opposite direction and thus be reflected back to the station or location of the origin of the sound." It is well known that he denied emphatically that there could be any such thing as an accidental acoustic cloud which could by any possibility return such an echo.

I am strongly of the opinion that Dr. Tyndall may be more than half right in emphasizing the importance of this phenomenon, though I agree fully with Prof. Henry in the belief that acoustic clouds have almost nothing, or, at least, very little to do with this or any other of the phenomena in question. In studying this echo the best plan would appear to be to collect all the

cases that have been noted, as this may lead to some common condition in all, which would give a plausible explanation of the mystery.

First. The first definite mention and observation, so far as I know, was in June, 1822, while Arago and others were conducting researches into the velocity of sound between Villejuif and Montlhéry, near Paris. Tyndall says: "It was observed and recorded at the time that, while the reports of the guns at Villejuif were without echoes, a roll of echoes, lasting from twenty to twenty-five seconds, accompanied every shot at Montlhéry. Arago referred these echoes to reflection from the clouds." Dr. Tyndall thought that an acoustic cloud surrounded the first station and that prevented the echoes there.

Second. The next observation was by Prof. Henry in 1866, at East Quoddy Head, Maine.

Third. By Prof. Henry at Cape Elizabeth, Maine.

Fourth. By Dr. Tyndall at South Foreland as already noted, though the date may be before third. On Oct. 17, 1873, the duration of the echo was fifteen seconds, and on this day the siren was heard nineteen miles. He ascribes this to the distance of the acoustic cloud.

Fifth. By Dr. Tyndall at Dungeness.

Sixth. By Prof. Henry at Block Island, R. I.

Seventh. By Prof. Henry at Little Gull Island. In some of these the siren was pointed upward.

Eighth. At Prof. Henry's suggestion, the sirens at Point Judith and Block Island were blown each Monday for a year, and the observer at each station was asked to listen to the echoes. Besides these, there are a number of minor cases but they are of no importance in this discussion.

These echoes seem to start even before the last portion of the blast of the siren has stopped. They were particularly plain in the case of the cannon shots. They were constant as to being heard, especially at South Foreland, but they differed widely as to the length of time each continued, and here also it was noted that the continuance of the echo seemed to be dependent upon the clearness of the atmosphere to the passage of the sound, that is, the echoes were much longer continued on those days when the sound was the farthest heard. It is to be regretted that we have no observations of the wind in connection with

these echoes, for it seems as though some of the facts might be explained better if the direction of the wind were known.

The Environment of these Points.

At Montlhéry, where these echoes were very remarkable, it is probable there was quite a cliff, possibly 150 or 200 feet high, though I have been unable to obtain the true state of affairs after an afternoon's search. The "Mont" in the name indicates quite an elevation, and it would have been difficult to see the flash of the cannon unless it had been upon quite an eminence. The barometer reading showed that this place was at least 100 feet higher than Villejuif, and a friend says there is a gentle slope from Villejuif down in the direction of the other station. On the other hand, at Villejuif, where there were no echoes, the ground is nearly level. Of East Quoddy Head, Me., there seems to be no information extant, but West Quoddy Head is 80 feet above the water. Cape Elizabeth is 143 feet, and there is quite a background there. South Foreland, as we have just seen, is on a cliff 235 feet above the water. Dungeness is also on a cliff, but I can find no information as to its exact height; it must be not far from 200 feet. Block Island is on a sharp cliff and the height is 204 feet. At Little Gull Island, when the trumpet was pointed vertically upward, its mouth was not far from 40 feet above the water. At Point Judith, there is quite a land surface as background. Unfortunately, we have no definite information as to the intensity of these ærial echoes at any of these places except Montlhéry and South Foreland, and here they were rather sharp and long continued. I presume without doubt they were much stronger at all stations at some height above the sea.

All echoes were most carefully listened for in the recent trip on the "Clover," but none of this description were heard. There can be no question but they are connected in some prominent way with the situation of the instrument, and their prolongation must also be dependent upon the wind. It seems incredible that there can be a convenient acoustic cloud always situated near the source of sound, for the echo begins at once, and just long enough to give back a sound of varying continuance on different days. Moreover, this supposition is disproved from the fact that no echoes were heard at Villejuif, although

here it was assumed that an acoustic cloud prevented their observation. If these echoes are due to acoustic clouds there is no reason why they should not be heard at sea level stations. In fact, it was very unfortunate that all the English researches were upon a cliff 235 feet high. It is hardly probable that the waves of sound can be bent around in a circle so as to come back to the observer. Moreover, the fact that the echo began at once precludes the possibility of such an explanation. It always comes in exactly in the line of the trumpet axis. Can it be possible that the loud blast impinges upon the quiescent air in such a way and upon such a large circle of such air off a high cliff, that a slight sound is returned? It is believed by some that the report of a cannon is caused by the stroke of the gases of combustion upon the air, and in like manner the noise of thunder is due to the violent rupture of the air by the electricity of the flash. It is very much to be desired that most careful observations of this echo be made, especially in connection with the topography of the signal station.

Audibility.

Some 300 years ago (I find no earlier reference), it was remarked that when sounds could be heard with unusual plainness, it was a sign that a storm was approaching. This phenomenon has been called "audibility." This condition of the atmosphere which renders all sounds peculiarly distinct, and enables their observation at very great distances, is entirely independent of the wind, moisture, temperature, pressure, etc. It is dependent upon a peculiar condition which accompanies our storms. Just what its cause is, it is difficult to tell. It is highly improbable that it is due to a more or less complete removal of flocculence, or to an unusually homogeneous atmosphere. It would seem that this may be a very important factor in explaining some of the puzzles that have been noted. We now need many careful observations of this phenomenon under all conditions of weather, and at all heights.

Diminution of Intensity of Sound with Distance.

It has been assumed generally that all sounds diminish according to the inverse square of the distance; that is, if the distance is doubled, the intensity is but $\frac{1}{4}$; at three times the distance it is $\frac{1}{9}$,

and so on. In a series of runs away from and toward Boston Light fog signal it was found that this law did not hold even approximately. The dropping off of the sound in the first three miles was very nearly according to the law, but after that the sound was heard on and on, to a distance of 13 miles in one case, with but a very slight diminution. This would also seem to be an important factor in any accurate studies. If we take the sound when just heard as our criterion in these studies we shall meet with very great difficulties, owing to the great uncertainties in the sounds when they are so weak. Any aberrations which may be found at distances greater than 3 miles with a first-class siren should be looked upon with suspicion, and this distance is much less with the whistle.

I will give now the conclusions arrived at by Prof. Mohn, of Christiania, after he had tried some experiments on fog signals at Färder, an island off Norway. Here there were in 1890 two steam sirens at a height of 93.5 feet above the sea. The trumpet mouth of the one pointed N. 86° E. and of the other S. 44°W. In the experiments the S. W. siren was sounded 0 to 13m., and 30m. to 43m. each hour, and the east siren from 15m. to 28m., and from 45 to 58. The sound was so regulated that each siren had two short blasts, each a second long (one following the other), one of them of a somewhat deeper tone. The observations were made from 9.00 to 16.00. Prof. Mohn's conclusions are as follows: —

"A ship master who believes himself near a fog signal, but in the fog can neither see nor hear it, must be uncertain as to the direction and position of the station, but it appears still that he can be within its range, can hit upon the earshot (Horweit) of the fog signal, and after that upon its measure. From observations of thermometer and anemometer at different heights, so far as the rigging gives opportunity, can he find $\Delta \tau$, Δe, and $\Delta \omega$, and thereby the earshot for the different azimuths and ear heights can he reckon. In case he finds a short ear-shot he is warned to be cautious though he does not hear the signal.

Moreover, I think that one can be given the following instructions in order to orient himself in a fog in the neighborhood of a fog signal station: —

The signal can be heard at a greater distance at some height than upon the deck.

When it is cold the signal cannot be heard as far as when it is warm.

In general a fog signal can be heard to the leeward farther than at right angles, and at right angles farther than to windward.

The greater the wind velocity the shorter is the ear-shot to windward, the farther to leeward.

In the same direction from a fog signal can the ear-shot of the signal quickly and directly change.

The higher above the sea the fog signal stands the greater will be the ear-shot of the signal."

General Remarks.

There is no necessity of giving farther details of previous experiments. I am sure that every one will recognize the extremely hazy condition of all investigations and theories on this subject. Aside from the fact established by Prof. Henry, that a sound can be heard about twice as far with the wind as against it, and that, in general, it can be heard farther at some height above the deck than at the level of the sea, there is hardly a single point well established. To go to a signal station and order up steam and then cruise around listening for the audibility of the sound is very interesting work but it is very difficult to get at anything in that way. We have thousands upon thousands of such observations but they cannot be utilized except for the roughest generalizations.

Let us imagine a powerful trumpet or, if one pleases, two powerful first-class sirens, pointing in different directions. Then let us consider that some of these have a very different environment from others, that the heights are different, the amount of steam used is different in the same signal at times. Let us consider that this powerful siren throws a tremendous beam of sound in its axis, heard at times to a distance of thirty miles, that this sound dies off very rapidly to the left and right of the axis. It seems to me that we need not be at all surprised at the dire confusion into which this whole subject has come. We do not know to-day the normal distance to which a twelve-inch whistle can be heard in a perfectly calm air. We do not know the exact effect of a varying velocity in the wind upon a whistle in the open, at some height above the sea. We do not know

anything of the effect of placing a whistle at different heights above the sea, both in a calm and in a wind. Until we can ascertain a few facts from a constant source of sound unaffected by a trumpet, or by topograpy, and under known conditions of wind, we cannot hope to make any real headway.

The evidence points very strongly against the use of sirens or trumpets in any but a few exceptional cases where a very long range is demanded, and even then so variable are the conditions of the sound a few hundred feet from the axis that it is an open question whether a whistle would not be better, supplemented by other whistles at points farther down the harbor. Of course, in the neighborhood of a large city an enormous whistle would be an abomination, but the sounds might be very materially reduced, if not wholly silenced, by building a barrier in the direction it is desired to cut off the sound.

The question of silent areas is especially puzzling. These can be elucidated much better with a whistle than with a siren. A most careful watch was instituted for these in Boston harbor, where it was said they had been noted, but nothing of the kind was observed. At Point Judith, a silent area was observed several years ago, and a bell buoy was established there to mark the area, but careful investigation in 1893 showed nothing of the kind; in fact, the hearing at the buoy was exactly normal, or the same as at other points similarly situated as respects the axis and the signal station.

With a wind blowing into the alternate contractions and expansions of the atmosphere, produced by a powerful source of sound, we may well expect to find, especially at a distance of one or more miles, remarkable variations. We ought to know what effect can be traced to the topography, to the height of the signal above the sea, to the angle of direction of the wind, to the velocity or variability of the wind, etc. Why may there not be a reflection of a beam of sound from the sea surface which interferes with other beams coming directly from the signal? Such an interference would undoubtedly quench both sounds and give a silent area. Such interference would be much more liable to occur the higher the signal above the sea; and it is a remarkable fact that the most persistent and widest extended silent areas are near signals of a considerable height above the sea. That a signal should be heard beyond a silent area would

not be at all difficult to explain, because there would be other direct beams of sound that would reach the ear beyond the interference area. We need most careful observations of this silent area region, in winds from all directions and of all velocities. We should study, also, the effect of topography, height of signal, etc.

The laws of the propagation, reflection, interference, etc., of weak sounds have been carefully and laboriously investigated in our laboratories, and these laws are perfectly well understood, but great care must be taken in going from such puny experiments to the effects of the powerful sounds made by steam sirens to be heard as many miles as the sounds of the laboratory can be heard feet.

It is known that the wind does not have a steady velocity or direction but both are continually changing. In these winds there are vortices. In fact, it is impossible to estimate the rapid variations in our winds. If our sound waves are due to alternate contractions and expansions in this air which is continuously changing, may we not consider that the effect of an opposing wind must be of a very different order from that of a favoring one? But this effect certainly cannot be due to a change in velocity as we rise above the sea. The experiments of Prof. Mohn, showing that a rapid favoring wind carried the sound farther than one that was slower, is strong evidence that the ordinary explanation is untenable.

The fact that in a snow-storm a sound is propagated in the teeth of a strong wind is an extremely important one. Surely here if ever the theory of refraction by a wind should apply. Do the snow-flakes form more or less of a solid for the better transmission of sounds? It does not seem necessary to consider that this solid should be continuous in order to give this effect.

It is my impression that the crying need to-day is for a series of experiments from a rock or very low island with open water for 10 miles on all sides, using a 12-inch steam whistle and with a pipe which will enable one to vary the height of the whistle 100 or 150 feet above the water. A careful series of experiments under these conditions would be invaluable for elucidating many perplexing phenomena, and would give a good foundation for investigating and explaining many if not all abnormalities.

CURRENT NOTES.

*Sensible Temperatures, or The Effect of Heat on the Body in California.** — Much has been said and written of the climate of California, of its sunshine, its rainfall, its temperature, and of all phases of the weather, but seldom is anything said of the effect of the heat in California. It is well known that on account of its long sea coast, its mountain ranges, and its latitude, that within the confines of the State may be found any climate that may be desired. The snow-capped and higher mountain regions have temperatures equal to the Arctic region, the plains and valleys, especially of the southern portion, have temperatures at times of the Torrid Zone. The greater portion of the State has a pleasant mean between the two, while the immediate coast has a climate free from heat and free from cold.

Over the great valleys of the Sacramento and San Joaquin, and over that large area of the State removed from the immediate coast and south of the Tehachapi mountains, maximum temperatures of from 106° to 118° are experienced during the summer months, and as high as 122° have been recorded in Death Valley in July. These abnormally high temperatures are sufficient to kill a human being, and would kill if it were not for the safeguards with which nature has provided all forms of life. The temperatures noted are from weather bureau records and show the temperature of the air, the thermometer being in the shade in a standard thermometer shelter. The reason that these temperatures do not kill is that while the degree of heat noted is that which is actually recorded, owing to causes which will be explained, that which is known as the sensible temperature is about 40° less, dependent upon the amount of moisture in the air, and it is this sensible temperature which affects life.

By sensible temperature is meant that which is felt at the surface of the skin, where the skin is exposed, as on the face or hands. The body when in a healthy state is constantly furnishing moisture to the skin which in cases exudes and stands in drops or, as they are called, "beads of perspiration." This moisture is evaporated by the air, and hence the cooling of the skin. The cooling effect of the evaporation is the safeguard against injurious effects by extreme heat. This cooling of the skin then subjects the body to the direct effect of the sensible temperature. This temperature is obtained from what is known as the wet bulb thermometer, *i. e.*, a thermometer having its bulb incased in a piece of muslin, to which is attached a piece of wicking, which latter, ending in a cup of water, by the capillarity of the cotton wicking the bulb is kept moistened, hence its name, — wet bulb ther-

* Issued by Mr. B. S. Pague, Local Forecast Official, San Francisco, Cal., July 27, 1895.

mometer. Dependent upon the dryness of the air does the evaporation from the wet bulb ensue, and the temperature shown by the wet bulb thermometer is the sensible temperature. For example, at San Francisco on June 29, 1891, a temperature of 100° was recorded; at the same time the wet bulb thermometer showed a temperature of 62°. While the air surrounding the body had a temperature of 100°, yet the air being dry, and evaporation from the body being great, the body, or the blood of the body, was subjected to a temperature of but 62°; this, of course, to a person in normal health and in the shade. When water is changed from the liquid to the vapor condition, a certain quantity of heat is utilized, which, on evaporation, is changed to latent heat, and is thus no longer sensible. A feeling of coldness, therefore, results from the change, and as long as evaporation continues the surface where it takes place is cooler than the general temperature of the surrounding air. When one is heated a fan is used to give relief and make comfortable. The motion of the fan causes a more rapid movement of the air; this air moved by the fan against the face has the same temperature as that which is not so disturbed. The cooling effect comes from the more rapid movement of the air produced by the motions of the fan which causes more rapid evaporation of the moisture on the face and exposed portions of the body, hence a more rapid cooling effect, and the temperature of the air felt by the face under the influence of the fanning is the sensible temperature.

The months from June to September are the warmest months of the year, and the records of the past five years have been used to deduce the following: Along the coast line from San Francisco north, the average maximum temperature during summer is 65° and the sensible temperature is 55°. South of San Francisco, along the coast line, the average maximum temperature is 70° and the sensible temperature is 57°. In the Sacramento Valley the average maximum temperature is 87°, the average sensible temperature is 65°. In the San Joaquin Valley the average maximum temperature is 94°, the average sensible temperature is 63°. South of the Tehachapi Mountains and over southwestern Arizona the average maximum temperature is 102°, and the average sensible temperature is 70°. So it is seen that during the summer months while the average maximum temperature is high, except along the coast, the average sensible temperature is below 60° along the coast, and from 60° to 70° in the interior. The average maximum and average minimum sensible temperatures over California during the summer are from 52° to 72° along the coast, and from 52° to 65° in the interior.

The highest temperatures on record at San Francisco during the months from June to September inclusive, average 95°, while the sensible temperatures on the same days average 63°. At Red Bluff the average highest is 111°, and the average sensible 71°. At Fresno, average highest, 110°, average sensible, 68°, and at Yuma the average highest is 116°, and the average sensible temperature at time of highest air temperature is 73°. These comparisons show that the sensible temperature is, on an average, from 23° to 40° lower than the average maximum temperature, and that on the extremely warm days the sensible temperature is from 32° to 42° lower than the extreme air temperature. This shows that while high tempera-

tures prevails at periods of the year, the temperature which the body is required to endure is about 35° less than the air temperature recorded, and this difference is due to the amount of moisture in the air. If the air were as moist as is found in the region of the Great Lakes and along the Atlantic sea board, and the temperature as high as it now is at times, the effect of the heat would be to kill by what is called sunstroke the greater number of our population, to destroy vegetation, and to desolate the country that now produces as much and as great a variety as does the most favored section of the globe.

Sunstrokes are produced by heat and a moist atmosphere; these prevent evaporation and a cooling of the body. The normal temperature of the body in a clean, healthy person is 98.4°; if it is above 99.5° or below 97.3° some form of disease is clearly indicated. An increase of 1° temperature above 98.4° corresponds with an increase of ten beats of the pulse in a minute. If a patient is shown to have a temperature of 106° the prognosis is unfavorable, and 110° is almost certain to produce a fatal issue. Hence can be seen that evaporation is absolutely necessary to cool the body during high temperatures, else the blood becomes heated and death ensues. The conditions favorable to sunstroke are, anxiety, worry, or overwork, irregularities in food, and, in a marked degree, intemperance. One using beer, whiskey, or other blood-heating drinks is much more predisposed to sunstroke than one using cooling drinks or pure water. Personal uncleanliness which among other things prevents the healthy action of the skin, tight garments which impede the functions alike of the heart and lungs, and living in over-crowded and unsanitary dwellings have an equally hurtful tendency. To overcome the unpleasant and debilitating effects of heat as much as possible, a clean, healthy skin, good pure food and pure air are necessary, and alcoholic drinks should be avoided. To obtain the beneficial effects of the reduction of temperature by evaporation the shade must be sought and the direct sun's rays avoided. Beneficial effects may be incurred by a natural or artificial breeze or wind, and for parts of the body covered by clothing they may be obtained by adapting the clothing to the free passage of air and moisture. For hot weather and in the shade the color of the clothing is of less consequence than its texture, together with sufficient looseness to permit of the free access of air.

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eating birds, such as the scarlet hanger, flycatcher, and warbler, which winter mostly in the West Indies or further south, are as numerous as usual, the insect-eating birds that winter within the limits of the United States are very scarce. It is believed that the unusually cold weather of the winter and spring in the south killed many of these birds, and also, by causing the death of the insects on which they live, indirectly contributed to the death of many more. As a result of this absence of insect-eating birds an increase of insect pests in New England is to be expected, unless extra care is taken.

Hodgkins Fund Prizes. — The Committee of Award for the Hodgkins Fund Prizes of the Smithsonian Institution has completed its examination of the papers submitted in competition for the prizes, and has made the awards as follows: The first prize, of ten thousand dollars, for a treatise embodying some new and important discoveries in regard to the nature or properties of atmospheric air, to Lord Rayleigh and Prof. William Ramsay, for the discovery of *Argon*, a new element of the atmosphere. The second prize, of two thousand dollars, was not awarded, owing to the fact that no contestant strictly complied with the terms of the offer. The third prize, of one thousand dollars, was awarded to Dr. Henry de Varigny, of Paris, France, for the best popular treatise upon atmospheric air, its properties and relationships. In addition to those above mentioned, twenty-one papers received honorable mention. The authors of three of these were given honorable mention with a silver medal, and of six of them honorable mention with a bronze medal. The Committee of Awards consisted of Prof. S. P. Langley, Dr. G. Brown Goode, Dr. J. S. Billings, and M. W. Harrington, and the Foreign Advisory Committee, of M. J. Janssen, Prof. T. H. Huxley, and Prof. von Helmholtz. After the death of Prof. von Helmholtz, Prof. W. von Bezold was added to the Foreign Advisory Committee.

International Meteorological Committee. — The International Meteorological Committee, at its last meeting held in Upsala, in August, 1894, recommended that an International Conference of the same character as that of the one held in Munich, in 1891, should be held in Paris about the middle of September, 1896. According to "Nature" of July 4, a circular has been distributed announcing that M. Mascart has undertaken to make the arrangements necessary for the meetings of the Conference. The programme is to be prepared before the end of the present year, in order to give meteorologists, interested in the subjects proposed for discussion, time to formulate their views thereon.

American Association of State Weather Services. — The meeting of the American Association of State Weather Services, which was to have been held at Springfield, Mass., in August, at the same time as the meeting of the American Association for the Advancement of Science, has been postponed until Oct. 16 and 17, and the place of meeting has been changed to Indianapolis, Ind.

BIBLIOGRAPHICAL NOTES.

PROTECTION FROM LIGHTNING.

ALEXANDER McADIE. *Protection from Lightning* U. S. Department of Agriculture, Weather Bureau. Bulletin, No. 15. 8vo. Washington, D. C., 1895. Pp. 26, plates 13.

In this JOURNAL for August, 1894, pages 144, 145, we noticed the first edition of this report, which originally appeared as a "Circular of Information," issued by the Weather Bureau. The present edition is somewhat enlarged, and is published as Bulletin No. 15, in the admirable series of bulletins issued by the Weather Bureau after Prof. Harrington became its Chief.

The greater part of this Bulletin is the same as the "Circular of Information," but there are some additions. One of the most important of these is a set of "Directions for Procedure in Case of Apparent Death from Lightning," based upon Dr. Augustin H. Goelet's "How to Deal with Apparent Death from Electric Shock," revised and modified for apparent death from lightning by Dr. W. F. R. Phillips, of the Weather Bureau. In view of the great importance of this matter, we quote the following paragraphs: —

"All things considered, it is rational to attempt the resuscitation of those apparently killed by electricity, and, if not too long delayed, the effort promises fair chances of success, provided proper means are instituted. If the body has actually been submitted to a current of sufficient volume to produce destructive tissue changes, all efforts at resuscitation will, of course, be futile. If, on the other hand, only respiration and the heart's action have been temporarily arrested, there is a condition of syncope simulating apparent death by drowning or from anæsthetics, and the physician knows that patients in this condition are frequently revived. Laymen will appreciate the nature of this condition if it is explained as one of exaggerated faint, and would not feel appalled upon encountering it if previously instructed how to cope with it. In an ordinary fainting spell the necessity to stimulate is universally appreciated. In syncope resulting from an electric shock stimulation is likewise indicated, but more vigorous measures are required. This is the only difference.

"As said above, the direction to treat one shocked by electricity as one drowned may be misleading, as the conception of the layman of the necessities in this case would be to roll the body on a barrel. Let him understand that the condition is one of exaggerated faint; prompt stimulants are necessary. *The man must be made to breathe*, if this is possible, and the efforts to induce respiration must not be suspended until breathing is fully

and normally restored, or until it is absolutely certain that life is extinct. This cannot be assured in less than an hour's persistent, energetic, tireless effort.

"The body must be placed upon the back. A roll made of a coat or anything else convenient (*rolled*, not folded) is placed under the shoulders, and must be sufficiently large to so prop the spine up as to drop the head backward. The operator should kneel behind the subject's head, grasp the elbows and draw them well over the head, so as to bring them almost together above it, and hold them there for two or three seconds. Then he carries them down to the sides and front of the chest, firmly compressing it by throwing his weight upon them. After two or three seconds the arms are again carried above the head and the same manœuvre is repeated at the rate of fifteen or sixteen times per minute. At the same time the tongue must be drawn out to free the throat. This manipulation stimulates respiration in the following manner, viz.: when the arms are extended over the head, the chest walls are expanded, just as in inspiration, and if the throat is clear the air will rush into the lungs. When the arms are brought down to the sides of the chest, compressing it, the air is expelled, just as in expiration. . . . The operator must, however, appreciate the fact that this manipulation must be executed with *methodical deliberation* just as described, and never hurriedly nor half-heartedly. To grasp the arms and move them rapidly up and down like a pump handle is both absurd and absolutely useless.

"In addition to this, if an assistant be at hand, the tongue, held by a cloth or handkerchief to prevent slipping, should be seized and drawn forcibly out during the act of inspiration or when the arms are extended above the head, and when the chest is compressed it may be allowed to recede. The rhythmical traction upon the tongue is in itself an excellent stimulant of respiration. It acts not only by freeing the throat of the tongue, which may fall back and obstruct breathing, but also by reflex irritation, through the frænum or bridle under the tongue being drawn forcibly against the lower teeth." In addition to these measures, "it is important to maintain the warmth of the body by the application of hot flannels, bottles of hot water, hot bricks, warm clothing taken from by-standers, etc. Firmly and energetically rub the limbs upward so as to force the blood to the heart and brain. . . . When swallowing is established, a teaspoonful of warm water, wine, diluted whiskey or brandy, or warm coffee should be given. Sleep should be encouraged."

Another addition to the Bulletin in its present form is a consideration of the question whether thunderstorms are more destructive to barns after harvest than before. The reasons favoring an affirmative answer are two. First, that before harvest the stalks of the grain and grass act as conductors of electricity and serve as discharging points, neutralizing, to some degree, the electric stress in the air, while after harvest, when the fields are bare, the electric tension must be relieved through buildings and prominent features in the landscape. Second, barns filled with crops are warmer than empty ones, and more inflammable, and, if struck by lightning, are more likely to be destroyed by fire. Uprising warm currents of air are likely to form, which may play an important part in determining the line of discharge.

The Weather Bureau statistics show that previous to Aug. 1, 1894, 130 barns were struck, with a loss of $134,000, and after Aug. 1, 138 barns were struck, with a loss of $273,500. From this it appears that a barn is more likely to be struck when filled with crops.

The illustrations are mostly the same as in the previous edition. Additional views are given of a spire 198 feet high, built of brick and brownstone, struck July 29, 1894, and of a burr oak shattered by lightning March 15, 1894.

RAINFALL CHART OF BELGIUM.

A. LANCASTER. *La Pluie en Belgique.* Publication de la Société Belge de Géologie, de Paléontologie et d'Hydrologie. Premier Fascicule, 8vo. pp. 224, avec une planche et une *Carte Pluviométrique de la Belgique.* Bruxelles, 1894.

Mr. Lancaster has certainly given meteorologists a very valuable publication in his "*La Pluie en Belgique*" and the accompanying rainfall chart of Belgium. The work was brought out by the Belgian Society of Geology, Palæontology and Hydrology, under the patronage of the Ministry of Agriculture, of Industry, and of Public Works. The author is himself so well known all over the world, through his active interest in and his publications on meteorology, that when his name appears in connection with any publication it is a certain guarantee that whatever the book or chart contains is of the very best. It was Mr. Lancaster who established the rainfall service of Belgium in its present high state of efficiency, and it was largely through his efforts that the Belgian meteorological service was reorganized.

The text of the present work will consist of two or three volumes, the first of which has recently appeared. This part contains a summary of all the rainfall observations made in Belgium during the last century up to Dec. 31, 1892. The total number of stations is 282, and the total number of years of observations is 2,662. The number of stations with at least ten years of observations is 175. Monthly means and sums are given for the whole period, together with the altitude of the stations. An account of the physical features of the country and colored charts showing the different rainfall zones complete the volume.

The rainfall chart is a most admirable piece of work, both cartographically and meteorologically. It is drawn to the 400,000th of the true scale, and was prepared by the Military Cartographical Institute. There are thirteen different sets of shading used on it, to indicate as many different amounts of mean annual rainfall, and we are glad to see that all the coloring is in blue, rather than in a number of varying colors. The names of the cities and towns are printed in different kinds of type according to the number of years during which their observations were taken, four sizes of type being used, to indicate less than five years; five to ten years; ten to fifteen years, and more than fifteen years. By the name of each station is printed the amount of its mean annual rainfall, in millimeters. In addition, this

chart presents a complete revision of the water-courses and of the exact boundaries of the hydrographic basins.

Taken altogether this work of Mr. Lancaster's is most admirable. We most cordially commend the chart to the attention of teachers and students of meteoroiogy, as giving a very exact and a very clear picture of the distribution of rainfall in Belgium, as well as being a splendid specimen of cartographic work. The second volume will include various supplementary tables, *e. g.*, the distribution of rainfall by seasons, variability of rainfall, periods of drought and of humidity, maxima of thunderstorm rains, etc. A number of charts on a scale of 1–800,000th are to be issued, showing the mean seasonal rainfall, etc., and it is hoped to publish also a relief map of Belgium and a map of the *zones of permeability* of the surface soils.

The price of the first part of *La Pluie en Belgique* and of the rainfall chart is 12 francs, and orders may be sent to M. Nizet, 43 Rue de l'Orme, à Etterbeek (Bruxelles).

ANNUAL REPORT OF THE NEW JERSEY WEATHER SERVICE.

Fifth Annual Report of the Board of Directors of the New Jersey Weather Service, 1894. E. W. McGann, Director. 8vo. Trenton, N. J., 1895. Pp. 246. Charts 8.

Mr. McGann's Fifth Report of the New Jersey Weather Service gives abundant proof of the active work done during the past year in his State. The new features adopted have been the dissemination of the forecasts by mail from a number of display stations to 83 sub-stations, and the emergency warnings. The forecasts sent by mail are printed on large postal cards, by means of rubber logotypes, by the displaymen, and are then mailed to different postmasters in their vicinity. This plan has proved very successful wherever it has been adopted, and will undoubtedly be very largely extended in the future. The emergency warnings were sent during the year to nineteen stations where telegraphic facilities were provided, and where there were interests that could be benefited by local storm warnings.

Monthly reports were received from sixty-two stations, all the voluntary observers being furnished with standard instruments and instrument shelters by the State. There has been a marked improvement in the preparation of the reports and in the care of the instruments, and a deeper interest has been shown in the subject of meteorology, practical as well as scientific.

We are especially pleased to note the following paragraph in Mr. McGann's report: —

"As an experiment which has proved a success, six copies of the American Meteorological Journal were subscribed for and supplied to as many voluntary observers who, in turn, sent them to others, thus giving them a wide circulation." We have had occasion recently to refer to this matter of subscriptions to the Journal on the part of State Weather Services for their volunteer observers, and are very glad to note that the plan has proved a success in New Jersey. The Prussian Meteorological

Service sends the popular meteorological journal, *Das Wetter*, free of charge to its observers, who are thus kept informed as to the progress of meteorology in general, and, consequently, take more interest in their observations. We feel sure that our volunteer observers, who keep such careful and conscientious records, would do their work more intelligently and with more active interest were they to know something more of the progress of the science of meteorology than they gain from the tabular statements of their own observations and of those of their fellow observers in their own State.

The report presents eight charts of seasonal precipitation and of seasonal isotherms.

ANNUAL REPORT OF THE NORTH CAROLINA WEATHER SERVICE.

North Carolina Weather During the Year 1894. — Eighth Annual Report of the North Carolina Weather Service, H. B. Battle, Ph. D., Director, issued by the North Carolina Agricultural Experiment Station. 8vo. Raleigh, N. C., 1895. Pp. 256. Monthly precipitation and temperature charts.

The Eighth Annual Report of the North Carolina Weather Service starts off with the encouraging words: "The past year's work . . . indicates a steady growth in the usefulness of the service, without any increase in expenditures. The meteorological observers, displaymen, and crop correspondents, without whose assistance the State Weather Service could not exist, have faithfully performed the duties which they have voluntarily assumed in the interest of the State." During the year, reports were received from seventy-two stations, six new stations having been established. Sixteen hundred copies of the crop bulletin were distributed each week during the growing season, the number of crop correspondents being 365. The logotype system of distributing the weather forecasts has been adopted at several stations, and has been found of great benefit.

The report contains a *Brief Account of the River and Flood Service in North Carolina;* the annual summary and the monthly bulletins, each of the latter containing a chart of the normal temperature and normal precipitation for the month. The features of interest during the year were the annual deficiency in precipitation, which amounted to more than six inches, and the unusual warm spell during March, from the 1st to the 25th, when the temperature averaged 12° per day above normal. This was followed by a severe frost, which almost wholly killed the fruit crop. Six months were above the normal in temperature. The maximum annual precipitation was 67.11 in. at Falkland.